



Real-Time Underground Cable Fault Detection Using Arduino Platform

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Abstract – In today's world, underground power cables are an increasingly popular method of distributing electricity for power distribution networks because they provide increased safety and reliability and they are less susceptible to being affected by environmental disruptions. Locating faults in underground cables can be very challenging and time-consuming due to the fact that the cables are typically not easily accessed for inspection purposes. The proposed project will utilize an Arduino microcontroller to develop an underground cable fault detection system based on the microcontroller and voltage and current sensors and a display device to continuously monitor the cable's electrical properties. The fault detection system will use Ohm's Law to detect fault conditions such as line-to-ground, line-to-line, open-circuit and three-phase using the properties of electricity. The proposed project is cost effective and provides a user-friendly and reliable method for detecting faults within underground cable systems. The time required to detect faults will be significantly reduced, with maintenance costs decreasing and the average length of time to remain without being powered-up due to a fault also decreasing. The proposed method is suitable for use in Smart Grids, Industrial, and Community types of applications.

Keywords – Underground cable fault detection, Arduino microcontroller, Power distribution systems, Voltage and current sensors, Ohm's law, Smart grid applications.

I. INTRODUCTION

In recent years, the use of underground cables for power distribution has increased steadily, especially in cities where space is limited and reliability is important. Unlike overhead lines, underground systems are less affected by weather conditions and reduce the risk of accidental damage. Because of these advantages, many utilities are shifting towards underground cabling as a more dependable solution for electricity supply. Underground cable networks have become an important part of modern power distribution systems, especially in urban and industrial areas. Compared with overhead transmission lines, underground cables provide several advantages such as improved safety, better protection

from environmental disturbances, and a cleaner visual appearance in cities and residential areas [1]. They are also less vulnerable to weather-related damage, which helps improve the overall reliability of electrical power distribution.

Despite these advantages, detecting faults in underground cables remains a major challenge for power utilities. Since the cables are buried beneath the ground, faults cannot be easily observed or inspected visually. Locating the exact point of failure often requires specialized testing equipment or excavation along the cable route, which can be both time-consuming and costly [2]. Conventional techniques used for underground fault detection usually involve manual testing procedures and

require trained personnel to operate complex diagnostic equipment. These methods may also result in longer power outages while the fault location is being identified [3]. With the increasing demand for reliable power supply and the expansion of underground cable networks, there is a growing need for faster and more efficient fault detection methods. Automated monitoring systems based on embedded platforms provide a practical solution to this problem, as they can continuously observe electrical parameters and detect abnormal conditions at an early stage.

In this work, a real-time underground cable fault detection system based on an Arduino microcontroller platform is pro-posed. The system monitors voltage and current values of the cable using sensors and processes the data through the microcontroller to identify abnormal conditions. When a fault occurs, the system estimates the approximate distance of the fault along the cable and displays the information immediately. This helps reduce the time required for fault detection and makes maintenance work easier.

The remainder of this paper is organized as follows. The next section describes the experimental setup used for im-plementing the proposed system [4]. This is followed by the working principle of the underground cable fault detec-tion method. The simulation results and discussion are then presented to evaluate system performance. Finally, the paper concludes with a summary of the work and possible directions for future improvements.

II. EXPERIMENTAL SETUP

The experimental setup for the real-time underground cable fault detection system was designed to replicate practical fault conditions in a controlled laboratory environment [5], [6]. The objective was to create a simple and flexible arrangement where different types of underground cable faults could be introduced and studied without using an actual buried cable system. The overall circuit diagram of the proposed system is shown in Fig. 3. It illustrates the interconnection of the Arduino controller, sensing circuits, relay modules, and the cable simulation network.

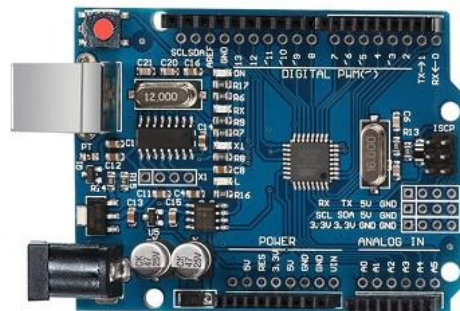


Fig. 1. Arduino ESP



Fig. 2. 16x2 LCD Display

The objective was to create a simple and flexible arrange-ment where different types of underground cable faults could be introduced and studied without using an actual buried cable system. The complete experimental setup of the project is shown in Fig. 4.

The system is built around a microcontroller-based platform, where an Arduino or ESP board is used as the main processing unit, as shown in Fig.1. The setup also includes a regu-lated power supply, a resistive cable model, fault simulation switches, sensing circuits, and a display unit Fig. 2. Since real underground cables are not easily accessible for testing, a resistor network is used to represent the cable, where each resistor corresponds to a fixed length. This makes it possible to simulate faults at different distances along the cable.

Fault conditions are introduced manually using switches connected at various points in the resistive network. When a fault is created, it results in a change in voltage and current values. These variations are detected by the sensors and sent to the microcontroller through analog input pins. The controller processes the data continuously and identifies abnormal conditions. Using Ohm's law, the system estimates the approximate distance of the fault from the source end [9], [10]. The fault type

and location are then displayed on the LCD screen, allowing quick identification without manual inspection.

This setup also allows repeated testing under different fault scenarios, which helps in evaluating the performance and response time of the system. The arrangement is simple, low-cost, and suitable for demonstration as well as practical applications [11], [12].

A. Components

The proposed underground cable fault detection system is developed using a combination of hardware modules that work together to monitor electrical parameters and identify fault conditions. The main components used in the system are described as follows:

1) *Microcontroller Unit (Arduino/ESP Board)*: As shown in Fig. 1, the microcontroller acts as the central processing unit of the system. It continuously receives input signals from the voltage and current sensors, processes the data, and identifies abnormal conditions. Based on the observed variations, the controller determines the type of fault and estimates its approximate location using Ohm's law. The processed information is then sent to the display unit. The Arduino/ESP platform is selected due to its low cost, ease of programming, and flexibility for future upgrades such as IoT-based monitoring.

2) *Underground Cable Simulation Network (Switch Array)*: The underground cable is simulated using a switch-based network, as shown in Fig. 3. Each switch represents a possible fault point along the cable length. By operating these switches, different fault conditions such as line-to-ground, line-to-line, and open-circuit faults can be created. This arrangement provides a safe and controlled environment for testing the system without requiring an actual underground cable.

3) *Resistor Network (Cable Model)*: A series combination of resistors is used to model the resistance of the underground cable, as depicted in Fig. 3. Each resistor represents a fixed segment of the cable length. This arrangement allows the system to estimate fault distance based on resistance variation. The resistor network plays an important role in simulating realistic cable behavior under different fault conditions.

4) *Voltage Sensor Circuit*: The voltage sensor circuit, integrated into the setup (Fig. 3), is used to measure the voltage across the cable. It converts the measured voltage into a suitable analog signal that can be read by the microcontroller. Any sudden drop or variation in voltage is treated as an indication of a possible fault condition.

5) *Current Sensor Circuit*: The current sensor monitors the flow of current through the cable. It detects abnormal increases or decreases in current, which are common during fault conditions. The sensed data is transmitted to the microcontroller for further processing. This component is essential for identifying short-circuit and open-circuit faults.

6) *Power Supply Unit*: The power supply unit provides a stable DC voltage to all components of the system. It typically consists of a transformer, rectifier, and voltage regulator (buck converter), as shown in Fig. 3. The unit ensures proper operation of the microcontroller and sensors by maintaining a constant voltage level and protecting the circuit from fluctuations.

7) *Relay Modules*: Relay modules are used as electrically controlled switches within the system (Fig. 3). They help in isolating faulted sections and controlling the flow of current in different parts of the circuit. Relays also provide electrical isolation between high-power and low-power sections, ensuring safe operation of the microcontroller.

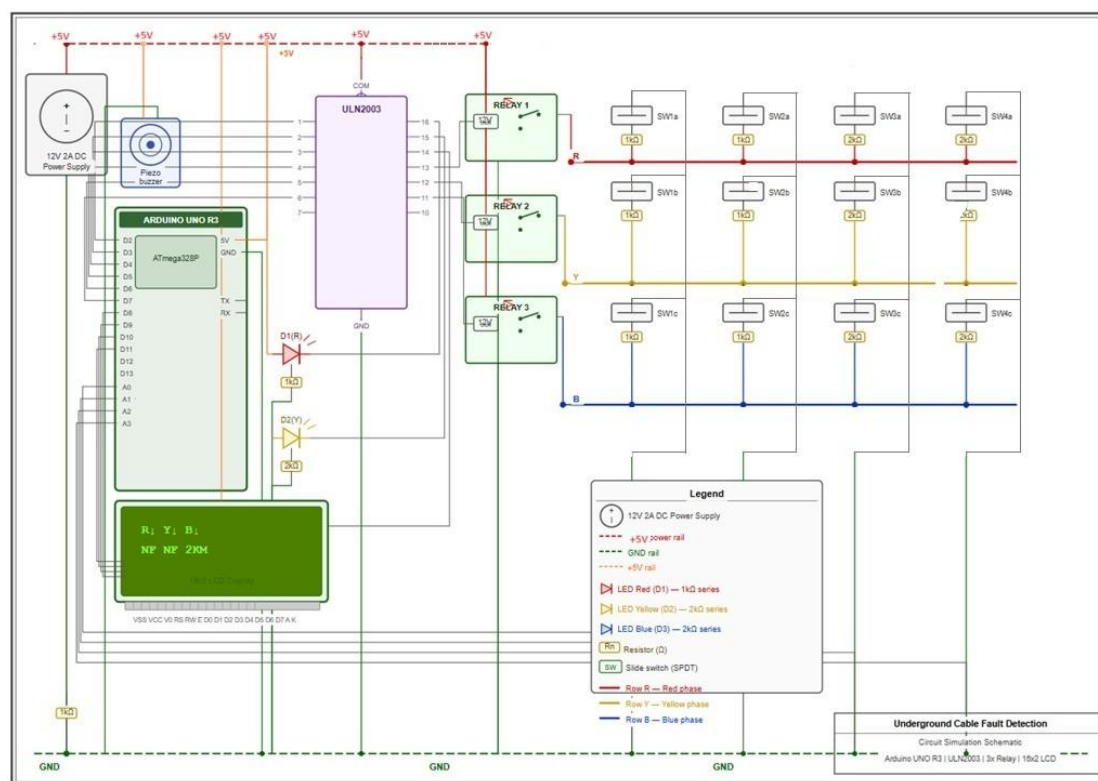


Fig. 3. Circuit diagram of the proposed underground cable fault detection system

8) *LCD Display (16×2)*: The LCD display, shown in Fig. 2, is used to present real-time information about the system. It displays the detected fault type, estimated fault distance, and overall system status. This allows the user to quickly understand the condition of the cable without additional equipment.

9) *Indicator LED*: An indicator LED is used to provide a simple visual indication of system operation. It glows during fault conditions or when the system is active, which helps during testing and debugging of the setup.

10) *Connecting Wires and PCB*: All components are inter-connected using connecting wires and mounted on a printed circuit board (PCB), as shown in Fig. 3. These elements ensure proper signal transmission, structural stability, and organized layout of the system.

III. WORKING PRINCIPLE

The proposed underground cable fault detection system mainly works on a simple electrical concept, which is Ohm's law ($V = IR$). In a normal condition, an underground cable behaves in a predictable way, where the resistance along its length remains almost

uniform. As a result, the voltage and current remain stable during normal operation [13].

In the developed setup, as shown in Fig. 4, the underground cable is not used directly. Instead, it is represented using a series of resistors connected together. Each resistor corresponds to a small portion of the cable length. This makes it easier to study the behavior of the system in a laboratory environment. Voltage and current sensors are connected at the input side of the setup to continuously measure electrical values. These measured signals are then given to the Arduino microcontroller for processing [14], [15].

When a fault is introduced in the system, such as a line-to-ground, line-to-line, or open-circuit fault, the normal flow of current gets disturbed. This disturbance causes a change in voltage and current values. In most cases, faults either increase or decrease the current suddenly, and this change can be clearly observed through the sensors. The microcontroller keeps checking these values and compares them with normal operating conditions. If a significant deviation is found, the system recognizes that a fault has occurred [16].

To find the location of the fault, the system uses the idea that resistance is related to the length of the cable. Since the resistance per unit length is already known from the resistor model, any change in resistance can be used to estimate how far the fault is from the starting point. The Arduino performs this calculation and gives an approximate distance of the fault. At the same time, it also tries to identify the type of fault by looking at how the voltage and current have changed [17].

Once the fault is detected and analyzed, the result is

shown on the LCD display. The display provides simple information such as fault type and its approximate distance. This makes it easier for the user to understand the situation without doing any manual calculations or testing.

Overall, the working of the system is straightforward and easy to follow. It uses basic electrical principles along with a microcontroller to detect faults quickly. The main advantage is that the system reduces the need for manual inspection and helps in locating faults in less time.

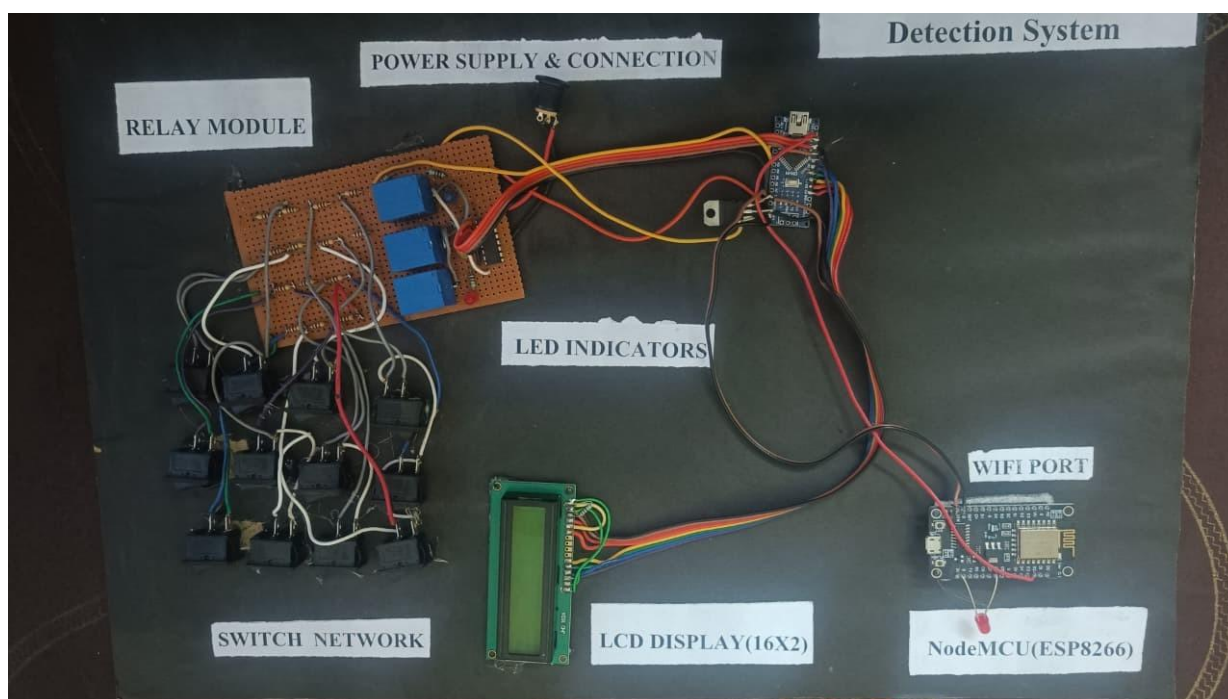


Fig. 4. Experimental setup of the proposed underground cable fault detection system

IV. SIMULATION RESULTS AND DISCUSSION

The proposed underground cable fault detection system was evaluated through simulation to understand how it behaves under different operating conditions. The idea was to check whether the system can correctly detect faults and give a reasonable estimate of their location along the cable. For this purpose, different scenarios were created in the simulation model, including normal operation as well as various fault conditions. These situations were generated by changing re-sistance values and current flow in the cable model.

Under normal operating conditions, the system showed stable voltage and current values along the entire cable. The sensors continuously monitored

these parameters and passed the data to the microcontroller. Since there were no disturbances, the readings remained steady, indicating healthy operation. This condition was useful as a reference to compare how the system behaves when faults occur.

When fault conditions were introduced, clear changes in electrical parameters were observed. In the case of a line-to-ground fault, the resistance of the affected section reduced, which caused an increase in current. This change was quickly detected by the system. The microcontroller processed the sensor data and identified the condition as a fault. It then estimated the approximate location by relating the resistance change to the cable length.

A similar observation was made for line-to-line

faults. In this case, the current increased suddenly due to direct contact between conductors. The sensors captured this abnormal rise, and the system recognized it as a fault condition. By looking at the pattern of voltage and current variation, the controller was able to distinguish this fault from others and calculate its approximate position along the cable.

Open-circuit faults were also tested in the simulation. Here, the current dropped sharply because the circuit path was broken. The system detected this drop without delay and classified it as an open-circuit condition. The microcontroller then estimated the fault distance using the same resistance-based approach.

One of the noticeable outcomes from the simulation was the fast response of the system. As soon as a fault was introduced, the change in voltage and current was detected almost immediately. The processing time was very short, and the result was displayed without any significant delay. This quick response is important in practical situations, as it helps reduce the time required to locate faults and restore power.

The simulation also included waveform analysis to study the behaviour of different circuit components. Parameters such as input current, output voltage, and stresses on switches, inductors, capacitors, and diodes were observed. During normal conditions, the waveforms appeared smooth and stable. However, when faults were introduced, disturbances were clearly visible in the waveforms. These changes matched the expected behaviour of the system, which supports the correctness of the detection method.

Another point worth noting is the performance of the resistance-based fault location method. While the system may not always give the exact physical location of the fault, it provides a close approximation. This is usually sufficient in practice, as it helps narrow down the faulty section of the cable. Instead of checking the entire cable, maintenance work can be focused on a smaller region, saving both time and effort. Overall, the simulation results show that the proposed system can detect different types of faults and respond in a reliable manner. It is able to monitor electrical parameters, identify abnormal conditions, and estimate fault locations with reasonable accuracy. These observations suggest that the system can be useful for real-world

underground cable monitoring, especially where quick fault detection is required.

V. CONCLUSION

This work presents a simple underground cable fault de-tection system using an Arduino-based setup. The system monitors voltage and current values and uses these changes to identify when a fault occurs in the cable. From the simulation study, it can be seen that the system is able to detect common fault conditions such as line-to-ground, line-to-line, and open-circuit faults. It also gives an approximate idea of where the fault is located by using resistance variation, which makes the process of inspection easier and faster.

One of the main advantages of this approach is that it does not require complex equipment. The setup is built using low-cost components and can be implemented without much difficulty. The response of the system is also quite fast, which helps in reducing delay in fault detection and improving overall reliability.

There is still scope for improvement in future work. Features like wireless communication, IoT-based monitoring, or GPS support can be added to make the system more practical for real-time applications and smart grid environments.

REFERENCES

- [1] M. H. Rashid *et al.*, "Power Electronics: Circuits, Devices and Appli-cations, Pearson Education. review," *IEEE Trans. Power Electron.*, vol. 32, no. 12, pp. 9143-9178, 2017.
- [2] R. W. Erickson and D. Maksimovic', "Fundamentals of Power Electron-ics, Springer.
- [3] S. Ghosh and M. Chakraborty *et al.*, "Fault detection and location in underground cable system using microcontroller," *International Journal of Engineering Research*, 2019.
- [4] J. Arrillaga, N. R. Watson, "Power System Harmonics, Wiley.
- [5] A. R. Gupta, *et al.*, "Microcontroller-based underground cable fault detector," *IJEEE*, 2020.
- [6] J. M. Kharade and H. P. Patil *et al.*, " Fault Detection in Underground Cable by using Arduino, *Applied Science and Engineering Journal for Advanced Research*, vol. 4, no. 2, pp. 63-66, Mar. 2025.
- [7] S. Gouda, S. Sudhakar, V. J. Vinaykumarswamy, R.

- Singadi, and Navaprakash, *et al.*, "Underground Cable Fault Detection System, IJRASET, Apr. 29, 2023.
- [8] M. T. HOD, N. Nagabhushan, and P. C. H. Pushpanjali, *et al.*, "Smart System for Detection of Underground Cable Faults Using Arduino and Ohm's Law, ShodhKosh: Journal of Visual and Performing Arts, vol. 5, no. 1, 2024
- [9] A. Jangir, D. Jain, K. Nayak, and V. R. S. Mahala, "Density Based Traffic Control System and Emergency Vehicle Detection Using Arduino," *In-ternational Journal of Advanced Engineering, Management and Science*, vol. 11, no. 2, p. 609970, 2025.
- [10] S. A. Danole, A. S. Mane, and V. M. Heralge *et al.*, "Underground Cable Fault Detection, IARJSET, 2023.
- [11] S. Inampudi, R. T. B. Rajitha, K. Sawant, and L. Gaur *et al.*, "Under-ground Cable Fault Detection Device Using Microcontroller, IJRASET, 2022.
- [12] S. Kesavan and V. S. Srinivasan *et al.*, "Underground Cable Fault Analysis System Using Arduino with Bluetooth Controller, Int. J. Sci. Res. Sci. Eng. Technol., vol. 11, no. 4, pp. 169–175, Jul. 2024.
- [13] M. Dudi, M. Bhati, N. Sharma, N. Choudhary, V. Mahala, and J. Vijay, "Optimizing solar powered charging stations for electric vehicles: Integration of fast and slow charging with renewable energy sources," 2024.
- [14] Abhishek Pandey and N. H. Younan, *et al.*, "Underground cable fault detection and identification via Fourier analysis," IEEE, 2010.
- [15] Xia Yang *et al.*, "Fault location for underground power cable using distributed parameter approach, IEEE Trans. Power Syst., 2008.
- [16] V. Mahala, R. Saini, S. Sharma, R. Verma, and R. Jangid, "High step-up modified four phase interleaved boost converter with coupled inductor topology," in *Proc. 2021 Third International Conference on Inventive Research in Computing Applications (ICIRCA)*, pp. 129–134, 2021.
- [17] Md. Fakhrul Islam *et al.*, *et al.*, "Locating underground cable faults: A review and guideline for new development, IEEE, 2013.